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DENDROPHOMA LEAF BLIGHT OF STRAWBERRY

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DENDROPHOMA LEAF BLIGHT OF STRAWBERRY

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INTRODUCTION

During the summer of 1919 a serious leaf blight of strawberry was observed in several localities in Illinois and Indiana. At first it was regarded as an advanced stage of the ordinary leaf spot caused by *Mycosphaerella Fragariae* (Schw.) Lind., but a closer examination showed that even from the inception of the attack it had entirely different symptoms. A more detailed study revealed the presence of fungus fruiting bodies quite distinct from those of the leaf spot. The destructive nature of the disease and its apparently wide distribution seemed to warrant a more extensive study. The results of this investigation are given in the following pages.

SYMPTOMS

The lesions of leaf blight, even in an early stage, are much larger than the mature lesions of the ordinary leaf spot. Usually, only one spot appears on a leaflet, tho there may be from two to five. In an advanced stage the most common condition is a V-shaped dead area extending from the midrib or one of the larger veins to the tip or side of the leaflet with the apex of the V pointing inward.

The young spots are uniformly reddish-purple when they first appear and are almost circular in outline. As they enlarge the central area dies and becomes brown. Later, three zones may be observed (Fig. 1): (1) an outer purple zone about 2-3 mm. broad, which gradually shades off into the normal green of the leaf; (2) a light brown zone about 5 mm. broad; and (3) a central dark brown area 2-3 mm. in diameter which is sometimes covered with a white granular layer.

On the under surface of the leaf the symptoms are the same except that the hairy covering masks the colors and makes them appear lighter and less sharply defined.

When the spots occur between prominent veins they usually remain circular in outline until they are 1-2 cm. in diameter. If they occur on a prominent vein, and especially if on the midrib, they elongate rapidly and become elliptical in outline. The leaf area between the lesion and the edge of the leaflet becomes streaked with purple, the color being especially deep along the veins. Since the veins extend in a fan-like manner from the point of infection, the resulting lesion is the characteristic V-shaped discolored area described above. This area of leaf tissue remains alive for some time after it shows the purple discoloration but finally dies.

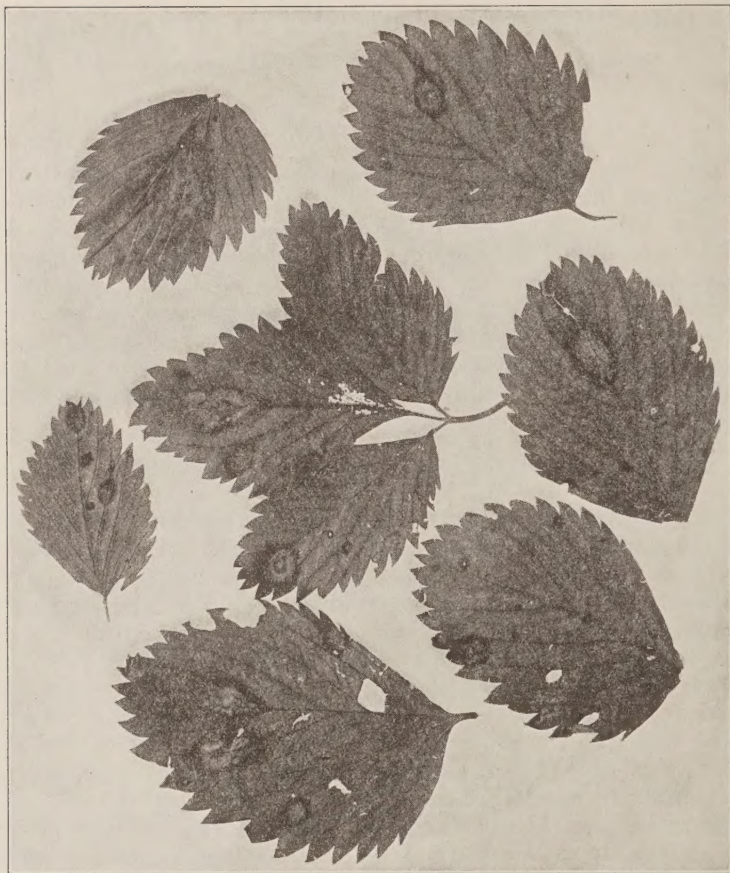


FIG. 1.—STRAWBERRY LEAF BLIGHT SHOWING VARIOUS TYPES OF LESIONS

The leaflet in the upper left-hand corner shows a typical fan-shaped dead area.

When the spots are a centimeter or more in diameter, small black dots, the pycnidia, appear scattered over the central dark brown area and to a certain extent in the lighter brown zone outside of this. These dots are present on both surfaces of the leaflet but are more evident on the upper. In some cases the pycnidia do not appear until a large area of the leaflet is dead.

In 1919, the diseased areas were evident as early as the first of June, but it is not known how much earlier they may appear. They are more often observed on the older leaves but are not uncommon on young, vigorous leaves. The spots continue to appear thruout

the summer and autumn. Half or two-thirds of a leaflet may die as a result of the attack and often entire leaves are killed. This results, of course, in a loss of vigor of the entire plant.

ISOLATION AND CULTURAL CHARACTERS

Isolation.—In order to determine the cause of leaf blight, the fungus evident on the diseased parts of a leaf was isolated and grown in pure culture. Some diseased leaves were placed in a moist chamber for several days. From the pycnidia abundant spores issued in short, thick threads (cirrhi). Agar plates were made from these in the usual manner and single spore cultures were obtained. Another set of cultures was obtained by crushing the pycnidia on sterile slides and pouring plates. In both cases it was comparatively easy to obtain pure cultures. Oat agar was found to be an excellent medium for isolation and was used in subsequent studies for growing the fungus. The cultures were kept in the incubator at 24° C.

Cultural Characters.—No extensive study of cultural characters was made. On apple-bark agar the fungus formed a heavy, white growth which was closely confined to the medium. The aerial mycelium was scant. Scattered stromatic masses were developed in most of the tubes. There were usually only three or four of these in each tube. Later, several pycnidial chambers were formed in these structures with ostioles extending in various directions, thus forming a studded structure from 2-4 mm. in diameter. The spores oozed in quantities from the ostioles after the culture was two weeks old. Single pycnidia were rarely observed on apple-bark agar; they were more common on plates than in the tubes.

Spores streaked on oat agar (Clinton's formula) resulted in a mycelial growth similar to that described above but even more closely confined to the agar. Abundant single pycnidia were formed over the surface of the agar within a week and the spores oozed from these in great abundance. The distinguishing character of the growth in oat agar, aside from the abundant production of pycnidia, was the production of a lemon-yellow pigment after five days. This was first noticed at the bottom of the slant but it gradually spread upward.

MORPHOLOGY AND LIFE HISTORY

Mycelium.—The hyphae remain light colored in culture for a month or more. There are no peculiarities in the branching or type of growth by which the fungus can be distinguished. In the leaf the mycelium penetrates all parts of the tissue.

Pycnidia.—The pycnidia develop beneath the epidermis. As they grow, the epidermis is pushed upward and finally ruptured in a star-

like manner. With a good lens the segments of the epidermis may be seen pressed against the surfaces of the protruding pycnidia. The pycnidia seem to be embedded more deeply in the tissues on the lower surface than on the upper. When placed under moist conditions, the pycnidia swell to several times their normal size and extend well above the surface of the leaf. The neck of the pycnidium is conical, thus making the entire pycnidium pear-shaped rather than flask-shaped (Fig. 2). The unusual length of the neck of the pycnidium



FIG. 2.—CROSS-SECTION OF A DISEASED LEAF, SHOWING THE LOCATION OF THE PYCNIDIUM AND THE EXTRUDING NECK
(Drawn by E. F. Guba)

is a striking characteristic of this fungus both on leaves and in culture, but this character is very variable.

The wall of the pycnidium is light brown under high magnification but the pycnidia are black to the naked eye. The walls are thin and delicate so that it is difficult to separate the pycnidia from the matrix of the leaf without rupturing them. The pycnidia are from 200 to 300 microns in diameter.

The spores issue from the pycnidia in long, thick, gelatinous cirrhi when the surrounding atmosphere is moderately humid. In about half the cases observed, the cirrhi did not arise from the ostiole but were pushed out from the side of the pycnidium. A few cases were noticed where two cirrhi originated from a single pycnidium, one on either side of the neck, or one arising from the ostiole and the other from the side of the pycnidium near the base of the neck. When first removed from a moist chamber, the cirrhi are thick and pearl colored; as the leaf dries, they shrink markedly and are honey col-

ored. When moist they are easily removed on the point of a needle, but when dry they are hard and tightly cemented to the pycnidium.

The spores exude from the pycnidia in the open when the leaf becomes moist. During a dry period in September, spores were observed exuding in the morning after a moderate dew, thus showing that rains are not necessary to supply sufficient moisture for spore exudation.

Spores.—The spores are hyaline, continuous, oblong-bacilloid, or narrowly ellipsoidal (Fig. 3). They are unusually narrow for spores of this genus. Two or three large granules usually are evident at either end, thus giving a characteristic appearance (biguttulate) to the spores under the high power of the microscope. Exuding spores on the leaf measure $5-7 \times 1.5-2$ microns, while in culture they are slightly larger. Freshly exuded spores are remarkably constant in size, rarely varying a micron in length.

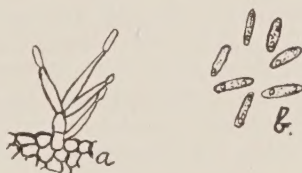


Fig. 3.—*Dendrophoma obscurans*.
(a) Branched conidiophore; (b) Pycnospore

The spores were germinated with difficulty in hanging drops of tap water. In agar plates only about 1 percent germinated. No explanation for this erratic behavior can be given. The pycnidia will exude spores at any time during the winter or spring when conditions are favorable. Leaves were brought into the laboratory every month from September until May, and when placed in a moist chamber soon began to exude spores in abundance. Cultures could always be made from the spores. This explains a possible source of infection in the spring.

Conidiophores.—These are peculiar in that they are quite long and distinctly branched. (Fig. 3.)

No perfect stage of the fungus was found altho repeated search was made on old leaves during the spring. This stage would not be necessary in the life history of the fungus since the pycnidia live thruout the winter and produce viable spores in the spring.

INFECTION EXPERIMENTS

Twelve strawberry plants were potted and all but the very young leaves were removed. These plants were allowed to grow undisturbed for three weeks and during this period no signs of the disease appeared on the leaves. Some older leaves were then removed and the young leaves left to develop. In several of the pots runners had been sent out and had developed new plants by this time. Four of the plants were sprayed with a suspension of spores from a pure culture, four were sprayed with a suspension of spores obtained from

diseased leaves, while the remaining four were sprayed with sterile tap water. The pots were covered with bell jars. After three days the bell jars were removed and the plants kept well watered. After ten days diseased spots appeared on several leaflets in all but one of the pots where the spore suspensions had been used, while none of the control plants showed any signs of the disease.

The lesions produced were typical except that the deep purple color was absent, probably owing to the lack of light in the laboratory and the succulent condition of the plants. It was expected that numerous lesions would appear on each leaflet inoculated, but as a rule there were only two or three and on about 50 percent of the leaflets no infection was evident. In some cases the leaflets blighted with no indication of a definite lesion and it was thought that these had been more or less heavily infected but that they had wilted so rapidly and completely that no fruiting bodies had been produced on them. No insects were observed on any of the plants from the time they were brought into the laboratory. Three of the infected plants died about ten days after the disease first appeared. These were discarded since the cause of their death was not thought to be due entirely to the fungus under consideration.

Two plants which had been infected with spores from pure culture were used to isolate the fungus. From the edge of a lesion on one of these plants, a pure culture was obtained from the mycelial growth in the tissue. Pycnidia were developed on the lesions of two leaflets of the second plant and a pure culture was obtained from the exuded spores.

HISTORY OF THE DISEASE

In 1893, Halsted¹ reported "a new strawberry blight" as follows: "Mr. F. L. Stevens, in 1892, while a special student in my laboratory and upon a visit to his home in Syracuse, New York, obtained specimens of a blight upon strawberry leaves which has been under investigation since that date, and upon which the following report is made." He then describes the symptoms, which correspond closely to those given above, and states that the disease was found in several points in New Jersey as well as in the neighborhood of Syracuse, New York. He believes that the fungus causing the trouble belongs to the genus *Aposphaeria*. He calls attention to the differences between this fungus and *Phyllosticta fragaricola* Desm. and Rob., which he states is a European species. The fungus is described in some detail and attention called to the prominent pycnidium. A recognizable figure of the disease is included. From the description of the symptoms and the figure presented, there is no question but that this is

¹Halsted, B. D. Diseases of the Strawberry. New Jersey Agr. Exp. Sta. Rpt. 14, 327-332. 1893.

the disease under consideration. He calls attention to the biguttulate spores, the prominent neck of the pycnidium, and the typical V-shaped diseased area. He regarded the pycnidium as superficial and hence placed the fungus in the genus *Aposphaeria*—a natural mistake when one does not have sections of the pycnidia to examine.

The fact that the fungus resembles a *Phyllosticta* naturally raises the question as to whether or not it is the same as *Phyllosticta fragaricola* Desm. and Rob. The spore sizes correspond closely but in other respects there is a decided difference. Two exsiccati specimens of *Phyllosticta fragaricola*, Roumeguere's Fungi Selecti No. 1327 and Rabenhorst's Fungi Europaei No. 1758, in the herbarium of the Department of Botany, University of Illinois, were examined. In both cases it was at once evident that the disease caused by this fungus is entirely different from the blight under consideration. The spots were much smaller, rarely exceeding 3 mm., with a striking white center. The disease caused by *Phyllosticta fragaricola* more nearly resembles our strawberry leaf spot (*Mycosphaerella Fragariae* (Schw.) Lind.) but the lesions are smaller and the centers whiter. *Phyllosticta fragaricola* is reported from London, Ontario,¹ and is common in Europe.

In 1894, Ellis and Everhart described a new fungus on cultivated strawberry which they called *Phoma obscurans*.² The description given by them is as follows:

"Spots 5-8 mm. in diameter with ferruginous center and broad purple border, paler below, perithecia few, scattered, convex prominent. Sporules oblong elliptical, hyaline, 2 nucleate, 4.5-5.5 $\times$ 1.5-2 microns. Basidia simple, lanceolate, fusoid, 8-12 $\times$ 1.5 microns.

"*Phyllosticta fragaricola* Desm. has similar sporules but the spots are much smaller with a white center. The basidia also indicate *Phoma* and not *Phyllosticta*.

"On leaves of *Fragaria* (cult.) Nuttallburg, West Virginia and Newfield, New Jersey."

The above description was repeated by Millspaugh and Nuttall in "Flora of West Virginia" in 1896.³ They give the type habitat "On leaves of *Fragaria* cult. July 8, 1894."

Two exsiccati specimens of *Phoma obscurans* E. & E., in the herbarium of the Department of Botany, University of Illinois, in Ellis and Everhart's North American Fungi, were examined. No. 3258 has the following label: "*Phoma obscurans* E. & E., Proc. Acad. Nat. Sci. Phil., 1894, p. 357. On leaves of cultivated strawberry, Nuttallburg, West Virginia, Nov., 1894, L. W. Nuttall." In this packet there are two leaflets with rather large spots in every way similar to those of the disease under consideration. No. 3444 has

¹Notae mycologicae. Ann. Mycol., 11, 546-568. 1913.

²Proc. Acad. Nat. Sci., Philadelphia, 1894, p. 357. 1895.

³Millspaugh, C. F., and Nuttall, L. W. Flora of West Virginia. Field Columbian Museum Publications, Botanical Series, 1 (1896), 107.

the following label: "*Phoma obscurans* E. & E., Millspaugh and Nuttall, Flora of West Virginia, 1896, p. 107. On leaves of cultivated strawberry, Nuttallburg, West Virginia, Sept. 1895, L. W. Nuttall." There are three leaflets in this collection, each showing one dead area of the typical triangular form on which abundant pycnidia are present.

The description of Ellis and Everhart is brief and the size of the spots here indicated is much smaller than the average found in the field. The exsiccata specimens show the spots much larger in most cases than indicated by the description.

A fragment of a leaflet from specimen No. 3444 was secured and from it a microscopic mount was made and spore measurements secured. The spore measurements and general character of the spores and pycnidia agreed closely with material from collections of the writer. The spore lengths given by Ellis and Everhart are somewhat less than those made by the writer from his material.

There is no question but that the disease described by Ellis and Everhart is the same as the leaf blight under consideration. It is evident that three collections were made, two by Nuttall in West Virginia (July 8, 1894, and September, 1895) and one in Newfield, New Jersey, at an unrecorded date, but during or before the year 1894.

TAXONOMY OF THE FUNGUS

It has been customary to restrict the genus *Phoma* to those species of the Sphaerioidaceae-Hyalosporae occurring on stems while leaf parasites are placed in the genus *Phyllosticta*. Ellis and Everhart referred the species under consideration to *Phoma* rather than to *Phyllosticta* on the basis of conidiophore characters. Just what constituted the basis of this distinction is not clear from their description.

Halsted called the fungus *Aposphaeria* on account of the supposedly superficial pycnidia. It is evident from Fig. 2 that the pycnidia are by no means superficial. *Aposphaeria* has short, unbranched conidiophores while in this species the conidiophores are distinctly branched.

Saccardo¹ erected the genus *Dendrophoma* to include all *Phoma*-like species having branched conidiophores. This genus is ordinarily described as having a papillate ostiole while the species under consideration has a rather long-necked pycnidium, which might be called rostrate. *Spaeronema* has as one of its distinguishing characters a rostrate pycnidium, but the neck of this genus is very long and the conidiophores are unbranched. Therefore, it would appear that the species under consideration has characters of both *Dendrophoma* and *Spaeronema*. On account of the fact that the neck is comparatively

¹*Michelia*, 2, 4. 1880.

short and the conidiophores are branched, the writer is of the opinion that this species should be placed in the genus *Dendrophoma* and proposes the new combination *Dendrophoma obscurans*.¹

OTHER LEAF-INHABITING FUNGI OF THE STRAWBERRY

The common leaf spot of strawberry due to *Mycosphaerella Fragariae* (Schw.) Lind. is the only other widely distributed leaf disease in Illinois. *Ascochyta Fragariae* Sacc. is reported as common in New York. This fungus produces a subcircular purple spot which becomes white with a dark purple margin. *Ascochyta Fragariae* has not been found in Illinois.

In May, 1883, Earle collected a fungus on strawberry leaves at Anna, Illinois, which Ellis and Everhart described as *Septoria aciculosa*.² No further mention of this fungus could be found by the writer. In April, 1920, Mr. E. F. Guba, an assistant in the Department of Horticulture, sent some dead leaves of cultivated strawberry plants to the writer from near Anna for identification of the fungus occurring on their surfaces. This proved to be the same *Septoria aciculosa* E. & E., collected thirty-seven years previously in this same locality. It has since been found to be widely distributed in this state. This fungus appears in dead or dying leaves of the previous season and there is no reason to believe that it is parasitic in nature altho most species of *Septoria* are classed as parasites. The distinguishing character of this fungus on the leaves is the presence of relatively large black spots, .5-1 mm. in diameter, which resemble small sclerotia. Under a lens these appear to be composed of grouped pycnidia as described by Ellis and Everhart.

CONTROL MEASURES

No experiments on the control of leaf blight were attempted in connection with this study. While the disease causes serious loss of functioning leaf tissues, it is not considered of sufficient economic importance to warrant spraying or other expensive control measures. Since infection evidently takes place thru the greater part of the growing season, it would be necessary to spray over a relatively long period.

¹*Dendrophoma obscurans* nov. comb. Spots large, .5-3 cm. or more; circular, oval, or sometimes fan-shaped; brown with broad purple zone. Pycnia scattered, amphigenous, flask-shaped, 150-300 microns, erumpent. Pycnospores hyaline, continuous, bacilloid or narrowly ellipsoidal, biguttulate, 5-7 x 1.5-2 microns. Conidiophores long, branched. On living leaves of cultivated strawberry.

²Torr. Bul., 11, 73. 1884.

The practice of mowing the leaves of the old vines and cultivating after harvest is believed to reduce the amount of trouble from this blight. On a patch where mowing was done the new leaves and young plants appeared almost free of the disease during the latter part of the growing season.

The practice of spraying strawberries for the common leaf spot and insect troubles has not become general in Illinois and unless more extensive damage should be done by this leaf blight in the future, it would not be considered advisable to make special applications of spray mixture for its control.